Auris Nasus Larynx 41 (2014) 558–562

Contents lists available at ScienceDirect

Auris Nasus Larynx

journal homepage: www.elsevier.com/locate/anl

Limited palatal muscle resection with tonsillectomy: A novel palatopharyngoplasty technique for obstructive sleep apnea

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ARTICLE INFO

Article history:
Received 8 November 2013
Accepted 5 March 2014
Available online 23 May 2014

Keywords:
Soft palate
Muscles
Operative surgical procedures
Obstructive sleep apnea
Snoring

ABSTRACT

Objective: The ideal palatal surgery for obstructive sleep apnea (OSA) and snoring must maintain the airway patency and correct anatomic abnormalities without complications. The purpose of this study was to investigate the efficacy of limited palatal muscle resection (LPMR) to improve OSA severity.
Subjects and methods: Twenty-three patients with OSA underwent LPMR. The LPMR was initiated with a bilateral tonsillectomy in patients with tonsil size 2 and 3. The LPMR consisted of partial resection of palatal muscles (levator veli palatini, palatoglossus, and musculus uvulae) with preservation of the uvula and a simple double layer suturing. The retropalatal space and the length of soft palate were evaluated by magnetic resonance imaging. Subjective outcomes using visual analog scales, Epworth Sleepiness Scale, and overnight polysomnography (PSG) data were assessed.
Results: Six months after the operation, there was significant symptomatic improvement in snoring, morning headaches, tiredness, and daytime sleepiness. Postoperative magnetic resonance images showed upward and forward movement of uvula and soft palate after LPMR. The length of the soft palate was significantly shortened and the retropalatal space was significantly increased. Postoperative PSG revealed significant improvement in apnea–hypopnea index (AHI) and the total sleep time spent with oxygen saturation below 90%, and reduction in AHI following PMR was found in all patients. Furthermore, no patient experienced velopharyngeal insufficiency, voice changes, and pharyngeal dryness at 6 months follow-up.
Conclusions: The LPMR obtained significant improvement in subjective and objective outcomes in OSA, with preserved pharyngeal function. PMR is an effective and safe technique to treat oropharyngeal obstruction in OSA surgery.

1. Introduction

The ultimate goal of surgical treatment for obstructive sleep apnea (OSA) is to improve symptoms and decrease cardiovascular morbidity and mortality by correcting anatomic obstruction and decreasing pharyngeal collapsibility [1]. Upper airway abnormalities amenable to surgery include those within nasal cavity, nasopharynx, oropharynx, and hypopharynx [2].

The oropharynx is one of the major areas of obstruction in the upper airway contributing to OSA. Consequently, uvulopalatopharyngoplasty (UPPP) that consists of removal of palatine tonsil, uvula, a portion of the soft palate, and the lateral pharyngeal wall is the most common surgical procedure performed for the treatment of OSA [3]. Although subjective improvement of symptoms including excessive daytime sleepiness and snoring is common [4], the response rate on objective assessment based on polysomnography (PSG) has been no greater than 50% [3,5]. Furthermore, UPPP has been associated with complications such as velopharyngeal insufficiency and nasopharyngeal stenosis [6,7]. Therefore, many modifications of UPPP have been proposed to

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http://dx.doi.org/10.1016/j.anl.2014.03.001
0385-8146/

contend with anatomical variations of the pharynx and minimize morbidities [8–12].

The soft palate is a complex structure composed of numerous pharyngeal muscles and connective tissues. The soft palate and uvula play an important role in the pathogenesis of OSA, however their function seems to be associated with oropharyngeal mucosa humidification [13,14]. Since the feeling of dryness in the throat is one of the most frequent complaints after UPPP, modifications in the original standard surgical technique, such as Han-UPPP [15], lateral pharyngoplasty [9], transpalatal advancement pharyngoplasty [12], and palatal implant [16], in order to preserve the uvula have been described.

The purpose of this study was to present the authors' preliminary results in the treatment of OSA patients using the technique known as limited palatal muscle resection (LPMR), which involves advancement and stiffening of the soft palate.

2. Subjects and methods

2.1. Patient selection

This study was approved by the Institutional Review Board of Pusan National University Hospital, and conducted from June 2010 to April 2011.

2.1.1. Inclusion criteria

Twenty-three consecutive patients who met all inclusion and exclusion criteria were considered candidates for LPMR. They must have experienced significant clinical symptoms of snoring, morning headaches, tiredness, daytime sleepiness and have been diagnosed with OSA, with an apnea–hypopnea index (AHI) >5 events/h.

All patients failed to respond to conservative measures, such as changes in sleep position and sleep hygiene, and were either intolerant or unwilling to use continuous positive airway pressure therapy.

2.1.2. Anatomic criteria for LPMR

Anatomic criteria for selection of LPMR candidates included (1) redundant posterior pharyngeal mucosa with formation of folds and low-hanging soft palate in the physical examination, (2) collapse of retropalatal space of 50% or more in midazolam-induced sleep endoscopy, and (3) classification of all patients as Friedman stage I and II [17] with Friedman tongue position I, II, or III and tonsil size 1, 2, or 3 (Table 1).

Table 1
Demographic characteristics of the OSA patient for LPMR.

Age (years)	36.8 ± 8.7
BMI (kg/m^2)	24.5 ± 5.6
AHI (events/h)	32.0 ± 10.2
FTP	
I	4 (17.4)
II	14 (60.9)
III	5 (21.7)
Tonsil size	
1	4 (17.4)
2	6 (26.1)
3	13 (56.5)
Stage	
I	12 (52.2)
II	11 (47.8)

Data are expressed as the number (percentage) except age, BMI, and AHI (mean ± SD). Bilateral tonsillectomy was performed only in patients with tonsil size 2 and 3. AHI: apnea–hypopnea index; BMI: body mass index; FTP: Friedman tongue position; PMR: palatal muscle resection.

2.1.3. Exclusion criteria

Subjects older than 60 years, morbid obesity (BMI > 35 kg/m^2), gross maxillary and mandibular deformities (mainly retrognathia) by the lateral cephalometry, macroglossia, and suggested presence of hypopharyngeal narrowing during midazolam-induced sleep endoscopy were excluded. Macroglossia was determined by the Friedman tongue position IV allowing the visualization of the hard palate only, and hypopharyngeal narrowing was defined by partial or complete obstruction of the hypopharynx and a portion of the oropharynx posterior to the tongue.

2.2. Surgical procedure

All the procedures were performed by the same surgeon under general anesthesia with oral endotracheal intubation. The patient was placed in the supine position and operative exposure was obtained with a Dingman mouth gag (Pilling Instrument CO., Philadelphia, PA). The LPMR was initiated with a bilateral tonsillectomy in patients with tonsil size 2 and 3. Tonsillectomy was not performed in patients with tonsil size 1, implying tonsils hidden within the pillars. The areas to be surgically excised were injected with small amounts of epinephrine (1:100,000) solutions (Fig. 1A). Oval shaped incision was designed using the monopolar electrocautery with a fine needle tip (Fig. 1B). The boundaries of resection were as follows: superior margin was 2 cm posterior to the hard–soft palate junction, inferior margin was the base of the uvula, and lateral margin was the superior extension of an imaginary line from tonsillar anterior pillar (Fig. 1C). The tissue in the oval shaped area including mucosa, submucosal adipose tissue, and partial layer of palatal muscles (levator veli palatini, palatoglossus, musculus uvulae) were dissected from the underlying muscles and removed using the monopolar electrocautery with a fine needle tip. The levator veli palatini was resected partially and superficially, with preservation of the deep layer (Fig. 1D). The palatal muscle was grasped and approximated with 2-0 Vicryl (Ethicon, Somerville, NJ) through an interrupted suture (Fig. 1E). Finally, simple suture of incised mucosal margin was done with 2-0 Vicryl (Fig. 1F).

2.3. Outcomes assessment

Each patient was evaluated preoperatively and at 6 months after the surgery. Outcome measures included subjective improvement in OSA-related symptoms based on the VAS and improvement in sleepiness as indicated by the Epworth Sleepiness Scale. Subjective OSA symptom scores were assessed with VAS ranging from 0 (irrelevant) to 10 (severely affected) for snoring, morning headache, tiredness, and daytime sleepiness. Bed partners of all subjects were requested to participate in the latter measurement.

The distance between the tip of uvula and posterior pharyngeal wall and the length of soft palate were evaluated in 10 patients who completed the magnetic resonance imaging preoperatively and at 6 months after surgery (Fig. 2).

Objective changes were assessed by the polysomnographic findings. Polysomnographic variables included the AHI, average oxygen saturation, minimal oxygen saturation, and the cumulative percentage of the total sleep time spent with oxygen saturation below 90% (CT90).

2.4. Statistical analysis

Data were presented as mean ± SEM. The data were analyzed using SPSS for Windows (version 16.0; SPSS Inc., Chicago, IL). Changes

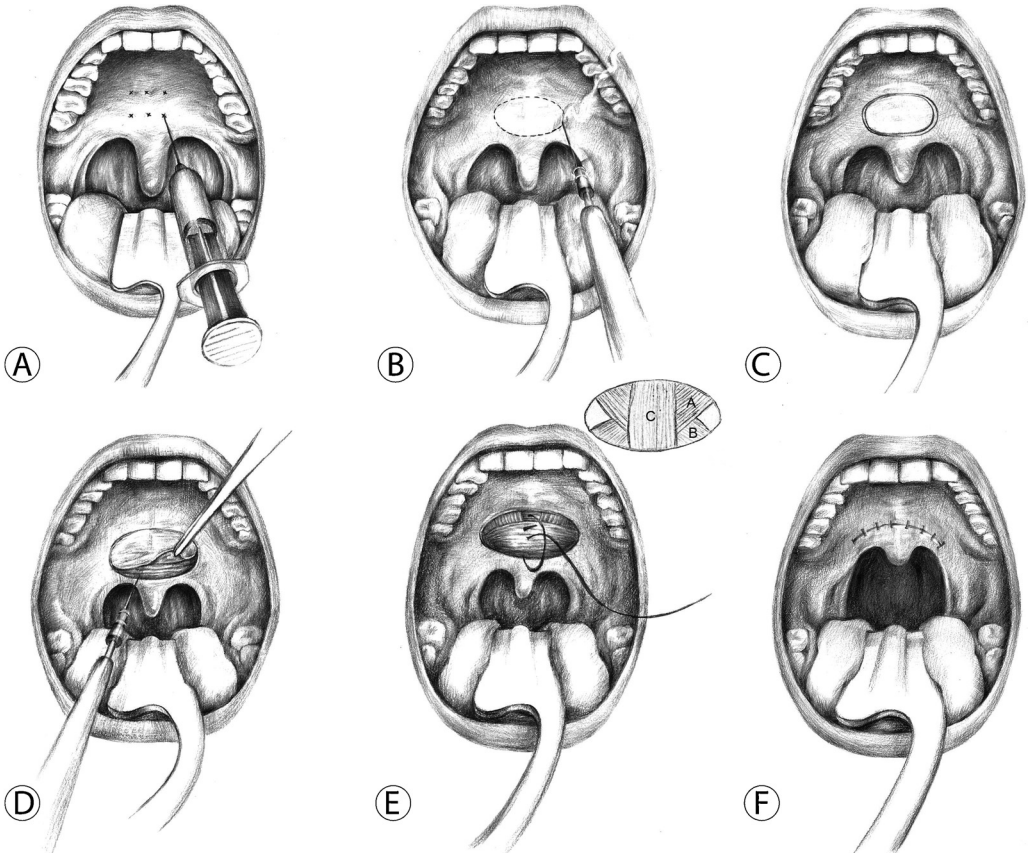

Fig. 1. Surgical techniques of limited palatal muscle resection. (A) After bilateral tonsillectomy, small amount of (1:100,000) epinephrine solutions are infiltrated into the planned surgical site. (B) Oval shaped incision is designed using the monopolar electrocautery with a fine needle tip. (C) The boundaries of resection are as follows: superior margin is 2 cm posterior to the hard–soft palate junction, inferior margin is the base of the uvula, and lateral margin is the superior extension of an imaginary line from tonsillar anterior pillar. (D) The dissection area is removed in oval shape including the parts of levator veli palatini (a), palatoglossus (b), and musculus uvulae (c). (E) The submucosal layer is approximated through an interrupted suture. (F) Simple suture of incised mucosal margin is done.

in OSA-related symptoms, the distance of retropalatal space, the length of the soft palate, and polysomnographic parameters before and after LPMR were compared using the Wilcoxon signed-rank test. A value of $p < 0.05$ was considered to be significant.

3. Results

From June 2010 to April 2011, although a total of 27 patients were enrolled in the study, 23 patients successfully completed all follow-up visits according to the clinical protocol, whereas 4 patients were not included due to follow-up loss and insufficient postoperative data. Twenty of 23 patients (87.0%) were male and 3 (13.0%) were female with age ranging from 21 to 58 years, mean age of 36.8 years. Preoperative mean body mass index (BMI) was $24.5 \pm 5.6\ kg/m^2$ (range, 17.4–30.9) and mean AHI was 32.0 ± 10.2 events/h (range, 21.5–49.3) (Table 1).

Fifteen patients had moderate OSA, and eight patients had severe OSA. The pre- and postoperative BMI showed no significant differences ($p = 0.835$). The mean snoring score using the VAS was significantly improved from 8.4 ± 1.6 to 4.0 ± 1.1 ($p < 0.001$). Furthermore, symptom scores for morning headache, tiredness, and daytime sleepiness were also significantly improved ($p = 0.002$, $p < 0.001$, and $p = 0.001$, respectively). Mean ESS score significantly decreased from 11.8 ± 3.1 to 6.0 ± 1.6 ($p < 0.001$) (Table 2).

Postoperative magnetic resonance images showed upward and forward movement of uvula and soft palate after LPMR. The length of the soft palate was significantly shortened from 28.3 ± 2.3 to 24.5 ± 1.9 mm ($p = 0.031$). Furthermore, the mean distance between the tip of uvula and posterior pharyngeal wall significantly increased from 5.1 ± 1.1 to 10.2 ± 1.5 mm ($p = 0.001$) (Table 3).

Analysis of the preoperative and postoperative PSG findings showed a statistically significant decrease in mean AHI from

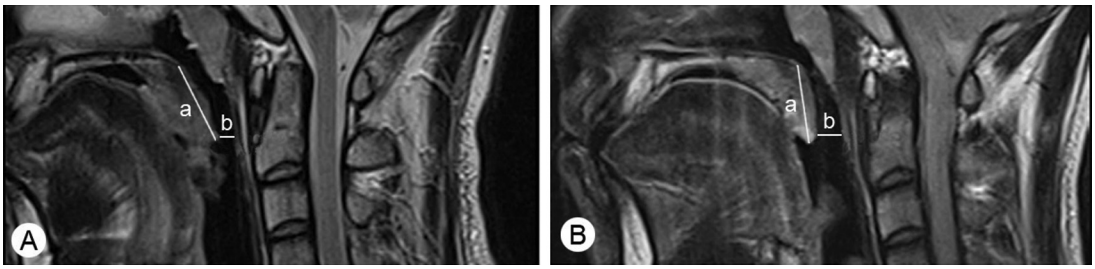

Fig. 2. Comparison of pre- and postoperative magnetic resonance (MR) image findings. Midsagittal MR images of pre-LPMR (A) and post-LPMR (B) showed that the length of the soft palate (a) is shortened and moves upward and forward. The retropalatal space (b), distance between the tip of uvula and posterior pharyngeal wall, is increased.

Table 2
Pre- and postoperative data of BMI, VAS, and ESS.

Parameter	Preop	Postop	*p*-Value
BMI (kg/m^2)	24.5 ± 5.6	24.6 ± 2.7	0.835
VAS			
Snoring	8.4 ± 1.6	4.0 ± 1.1	<0.001
Morning headache	3.3 ± 2.1	1.2 ± 0.4	0.002
Tiredness	5.5 ± 1.7	2.3 ± 0.9	<0.001
Daytime sleepiness	4.9 ± 2.6	2.1 ±1.1	0.001
ESS	11.8 ± 3.1	6.0 ± 1.6	<0.001

Data are expressed as the mean ± SD. BMI; body mass index; ESS: Epworth Sleepiness Scale; Preop: preoperative; Postop: postoperative; VAS: visual analog scale.

Table 3
Pre- and postoperative soft palate length, retropalatal space, and polysomnographic data.

	Preop	Postop	*p*-Value
Soft palate length	28.3 ± 2.3	24.5 ± 1.9	0.031
Retropalatal space	5.1 ± 1.1	10.2 ± 1.5	0.001
AHI (events/h)	32.0 ± 10.2	5.6 ± 3.1	0.001
Tonsil size			
1 (4)	31.9 ± 9.1	5.9 ± 2.8	
2 (6)	32.2 ± 10.9	5.3 ± 3.2	
3 (13)	31.7 ± 10.5	5.7 ± 3.2	
Mean SaO_2 (%)	95.7 ± 2.1	95.9 ± 1.7	0.982
Lowest SaO_2 (%)	83.2 ± 3.1	88.3 ± 1.9	0.098
CT90 (%)	13.0 ± 2.7	4.5 ± 1.1	0.007
Tonsil size			
1 (4)	13.0 ± 2.7	4.2 ± 0.8	
2 (6)	13.1 ± 2.8	4.4 ± 1.6	
3 (13)	12.9 ± 2.6	4.8 ± 0.8	

Data are expressed as the mean ± SD. AHI: apnea–hypopnea index; CT90: percentage of the time spent with oxygen saturation below 90%; Preop: preoperative; Postop: postoperative; retropalatal space: distance between the tip of uvula and posterior pharyngeal wall; SaO_2: arterial oxygen saturation.

32.0 ± 10.2 to 5.6 ± 3.1 ($p = 0.001$). Furthermore, CT90 were significantly improved from 13.0 ± 2.7 to 4.5 ± 1.1 ($p = 0.007$). Although average oxygen saturation and minimal oxygen saturation were improved after PMR, there was no significant difference between pre- and postoperative scores (Table 3).

No airway compromise was found in the postoperative period. We did not observe any postoperative wound bleeding in this study population. Additionally, there was no subjective nasal regurgitation, speech alternations, or taste loss observed 6 months postoperatively. No patient experienced surgical wound dehiscence.

4. Discussion

The mechanism of OSA is usually multi-factorial, and the obstruction in the upper airway is very likely to be multilevel, especially in moderate and severe OSA patients. Therefore, the success of surgery for treatment of OSA depends on the accurate diagnosis of the sites of obstruction and the appropriate selection of procedures to address these sites [2]. The palatal level is one of the major areas of obstruction in the upper airway contributing to OSA [18,19]. The goals of palatal surgery are to expand and open the oropharyngeal airway and to remove obstructing or redundant tissue leading to a reduction in the resistance to airflow [20].

UPPP, initially described by Fujita et al. [21], is used to correct obstruction at the palatal level by modification of the uvula, removal of redundant pharyngeal and palatal tissue, and primary closure of the posterior and anterior pillars to enlarge the retropalatal area. Although UPPP has become an excellent modality for treating specific anatomic obstructions at the palatal level, UPPP has several limitations including significant postoperative pain, pharyngeal dryness, persistent foreign body sensation in the throat, nasopharyngeal stenosis, and rarely permanent velopharyngeal incompetence [22,23]. In this study, considering the anatomy and function of soft palate, we suggested a modified UPPP, in which the mucosa of uvula is preserved and a portion of the palatal muscle is removed, allowing the retention of the normal shape of the uvula and soft palate. Furthermore, this study was performed in selected patients with only retropalatal obstruction suggested by Friedman staging system, cephalometry, and midazolam-induced sleep endoscopy to evaluate the subjective and objective outcomes of this technique.

Poor muscle tone in the pharynx and palate contributes to narrowing of the retropalatal space during sleep, possibly leading to failure in maintaining airway patency and ultimately partial pharyngeal collapse. Another contributing factor is the anatomic abnormality, that is, an elongated uvula and low-hanging soft palate that narrows the opening of retropalatal space and vibrates during respiration. Therefore, the ideal palatal procedure for OSA and snoring must maintain the airway stiffness and correct anatomic abnormalities without complications.

LPMR was attempted to shorten and tighten the soft palate with preservation of the uvula in order to increase the retropalatal upper airway patency. Partial resection of palatal muscle and double layer suturing shorten the redundant mucosal fold and low-hanging soft palate, consequently moves the soft plate in a forward and upward direction, thus likely enlarging the retropalatal airway space. Moreover, horizontal suturing incites fibrosis and creates scar tissue, resulting in stiffening the soft palate, with expected decrease in snoring, reduced collapsibility and therefore fewer apneic episodes. Although the cautery-assisted palatal stiffening operation (CAPSO) and anterior palatoplasty has similar core value [24,25], LPMR is a modification of the CAPSO and anterior palatoplasty with two important differences in the preservation of uvula and deeper resection of palatal muscle. First, although CAPSO and anterior palatoplasty were based on stripping of mucosa off the soft palate and uvula, LPMR involved the palatal mucosa and a portion of the palatal muscles. Therefore, LPMR may create a larger retropalatal space by more advancing and stiffening the soft palate. Second, instead of sacrificing the uvula in CAPSO, the uvula is preserved in LPMR.

The uvula has histologically unique structure and important physiological functions when compared with other parts of the soft palate. The uvula contains significantly more salivary glands with predominant serous type in comparison with the palatine arch tissue and plays a very important role in moistening the oropharyngeal mucosa [26,27]. Therefore, the preservation of the uvula and its mucosa may improve postoperative pharyngeal discomfort such as a foreign body sensation and dryness.

In this study, we evaluated the surgical efficacy with subjective questionnaires and objective polysomnography. Six months after the operation, there was significant symptomatic improvement in snoring, morning headache, tiredness, and daytime sleepiness. Postoperative PSG revealed significant improvement in AHI and CT90, and reduction in AHI following LPMR was found in all patients, although confounding variables were not considered in the statistical analysis. Furthermore, no patient experienced subjective nasal regurgitation, voice change, and pharyngeal dryness at 6 months follow-up. Another benefit of LPMR is that it is anatomically more sound because it causes scarring superiorly, avoiding the puckered scar and stenosis of the lateral nasal walls, and can be performed easily. The preliminary results support that LPMR leads to favorable response in the treatment of OSA and maintains pharyngeal function. To further investigate the impact of LPMR on swallowing and phonation, a study to compare pre- and postoperative changes in nasalance, nasality, voice, and articulation has been undertaken.

5. Conclusion

This study describes a modified palatal surgical technique to target retropalatal obstruction by advancing the soft palate in an attempt to enlarge the upper airway lumen and maintain the airway stiffness in a well-selected sample of OSA patients with high clinical and endoscopic likelihood of presenting strict retropalatal obstruction. The LPMR shows significant improvement regardless of tonsil size in subjective and objective outcomes of OSA patients with normal postoperative pharyngeal function and is an effective and safe technique to treat oropharyngeal obstruction in OSA surgical candidates.

Conflicts of interest

None of the authors have any potential conflicts of interest and financial support of work to declare.

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